Research Article

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Hard Water Tolerance of Mixed Surfactant Systems Containing Sodium Dodecyl Sulfate and Decyl Polyglucoside

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ABSTRACT

The objective of this research was to evaluate the efficiency of the mixed micelles of glucoside-sodium dodecyl sulfate surfactant for estimation of water hardness. The non-ionic glucoside surfactants have proved themselves as potential alternatives to the cleaning and washing commodity market, exhibiting effective hard water tolerance. The suitability of the glucoside surfactant for the lime soap dispersion ability was determined through the mixed micellization studies. The effect of incorporation of synthesized decyl polyglucoside to the anionic sodium dodecyl sulphate surfactant on the water hardness tolerance has been investigated through nephelometric measurements. No turbidity was observed up to 350 ppm hardness of water beyond 10% level of incorporation of APG_{10}. The plots of turbidity against water hardness for 1:0, 4:1, 2:1 and 1:1 calcium to magnesium ratio have revealed a linear variation of turbidity with hardness for a fixed surfactant concentration at 2.5 mM. In comparison, decyl polyglucoside was found to be better in hard water tolerance than anionic surfactants. Hence, it was concluded that with moderate foaming, decyl glucoside would be a better surfactant for making detergents to face water crisis.

Keywords: Detergency; Mixed micelles; Water hardness.

1. INTRODUCTION

Due to the cost escalation and increasing scarcity of petrochemicals feedstock, increased expectation in efficacy and safety of laundry detergents, the present study was focused on examining the mixed surfactant system as an alternate raw material for detergents. Anionic sodium dodecyl sulphate (SDS) surfactant has been well known for its efficacy and safety but suffers from poor performance in hard water due to the scum formation (Ansari *et al.* 2012; Naved Azum *et al.* 2016). On the other hand, it has now been revealed that the workability of SDS can be inadvertently improved in hard water detergency by the addition of nonionic surfactants (Geetha and Tyagi, 2016). These SDS-decyl polyglucoside (APG_{10}) combinations form mixed micelles in water and essentially take the surface active characteristics of a single anionic surfactant. SDS-APG_{10} combinations perform well in hard water without scum formation. SDS-APG_{10} combinations were at par with the conventional detergents in all performance and undergo biodegradation more readily.

1.1 Background of this study

Alkyl polyglucosides are one of the important classes of non-ionic surfactant by meeting the sustainable needs of the surfactant industry through its renewable raw material sources, biodegradability and nontoxic nature with greater compatibility with other surfactants (Ansari *et al.* 2012). Our present study was aimed at finding the suitability of the glucoside surfactant for the lime soap dispersion ability. Even though SDS is known for its ability, being an anionic surfactant, its performance has a drawback of poor hard water tolerance. Mixed micellization of SDS with water hardness tolerable APG_{10} may find solution to the existing water hardness problem. One of the objectives of this study was to know the influence of acid catalysts on the APG_{10} product composition; the other was to analyze the lime soap dispersing ability of APG_{10} with anionic sodium dodecyl sulphate and linear alkyl benzene sulphonate. The surfactants selected for this study have large difference in their critical micelle concentrations (CMC). The synergism of the mixed micelles have been analyzed with the help of molecular thermodynamic model and phase separation model of Rubingh and Clint.

2. EXPERIMENTAL METHODS

All reagents used throughout the study were used without any further purification. Sodium dodecylsulphate was purchased from Merck. The nonionic APG_{10} was synthesized, purified in laboratory. Double distilled water was used for preparing solutions.

2.1 Mixed Surfactant Solution

A mixture of surfactants was prepared from non-ionic APG_{10} and anionic SDS. The surfactants were mixed at various mole fraction (α) from 0.1 to 0.9. The surface tension of these mixtures were measured using Du-Nouy ring tensiometer (Platinum ring detachment method).

2.2 Determination of Hard Water Tolerance

The hard water tolerance of sodium dodecyl sulphate was measured by measuring the turbidity created through the lime soap dispersion of the surfactants. Nephelometer, which works on the basis of Tyndall effect, was calibrated by using the dilutions of a standard formazin stock solution. The change of turbidity of SDS with increasing concentration of SDS at different hardness *viz.*, 20 ppm, 50 ppm, 100 ppm and 150 ppm were also recorded. Standard hard water samples were prepared by dissolving calculated amount of $CaCl_2$ and $MgCl_2$. The same measurements were repeated with the incorporation of 10% aqueous solution of synthesized APG_{10} to compare their capabilities of water hardness tolerance.

3. RESULTS AND DISCUSSION

3.1 Micellar Interaction at various Mole Fractions

The micelles formed at the CMC were significantly influenced by the mixed surfactant system. The critical micelle concentrations of individual and mixed surfactants were determined by surface tension measurements at varying overall total concentration of the surfactant in aqueous solution at different mole fractions, at 32 °C. The results are plotted in Fig. 1. The concentration at which the break in the plot with the sharp reduction in the surface tension of the solution occurred was taken as the critical micelle concentration (CMC). As seen in Fig. 1, CMC values of the mixed surfactant system were lower than that of the single surfactants - 0.0249 M/L for APG_{10} and 0.008 M/L for SDS indicate the synergism. The experimental CMCs have been compared with the theoretical values which was calculated.

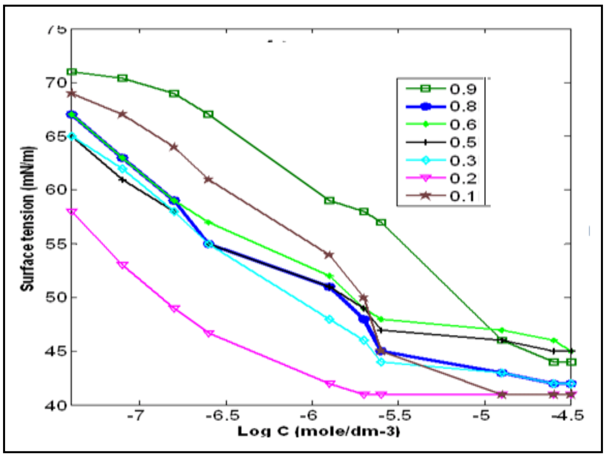

Fig. 1: Surface tension *vs.* Concentration plot for surfactant mixtures of SDS with APG_{10} at different mole fractions of SDS at 305 K

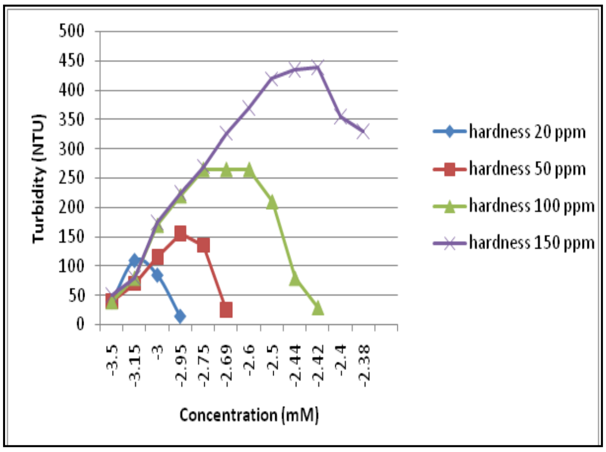

Fig. 2: Plot of Turbidity against logarithmic concentration of SDS in 10% APG_{10} at different water hardness

3.2 Hard Water Tolerance of APG_{10}

The determined values of turbidity as a function of surfactant concentration at various hardness of standard hard water were well-correlated with the already reported values (Geetha and Tyagi, 2016; Daz Geetha and Rashmi Tyagi, 2012). From this, it has been clearly proved that SDS-APG_{10} mixed micelles were more efficient than the SDS in the aspect of lime soap dispersing ability. In this connection, the mixed micelles were taken for further study. The turbidity values of SDS due to the scum formation at higher hardness were reduced to a considerable extent by the incorporation of 10% APG_{10} (Fig. 2). Being a non-ionic surfactant, the alkyl polyglucosides were not affected by the hardness-producing calcium and magnesium ions of the hard water. The testing system appeared clear (no turbidity) up to 350 ppm. Further, the turbidities of the aqueous solutions of SDS were measured as a function of hardness by fixing APG_{10} at 0.25 mM (Fig. 3). These plots can be used for the estimation of calcium and magnesium from unknown samples. Since this method involved graphical interpretation, it would be accurate and without the necessity of using harmful chemicals to estimate the hardness.

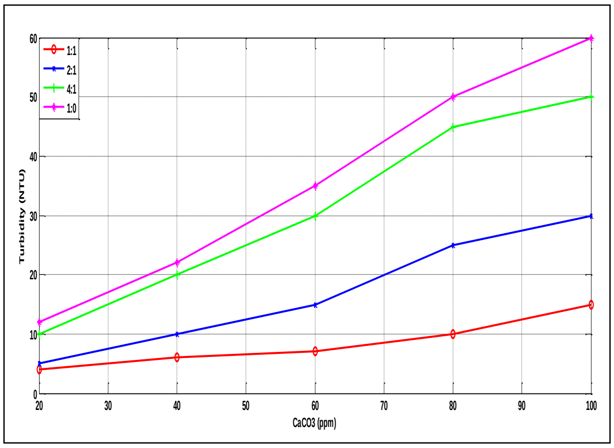

Fig. 3: Effect of calcium and magnesium hardness as $CaCO_3$ (ppm) on the turbidity at fixed concentration of SDS at 305 K

4. CONCLUSION

In summary, the results obtained from CMC and physico-chemical parameter evaluation have indicated the synergistic interaction between the mixed micelles. The mixed micelles of APG_{10}-SDS have higher tolerance over hard water than that of pure SDS surfactant. The formulation based on these micelles would be helpful to get the surfactants of desirable detergency. This surfactant has been utilized for the successful estimation of hardness. The hard water tolerance of the anionic SDS have been greatly improved by the incorporation of APG_{10}.

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CONFLICTS OF INTEREST

The authors declare that there is no conflict of interest.

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